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(54) **SUBCUTANEOUS FLUID PUMP**

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A61M 5/00 (2006.01)
A61M 27/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A61M 27/002*** (2013.01)

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CPC A61M 27/002; A61M 5/14276; A61M 27/006; A61M 5/1723; A61M 2205/3355; A61M 2205/8287; A61M 2205/1085
USPC 604/8–10
See application file for complete search history.

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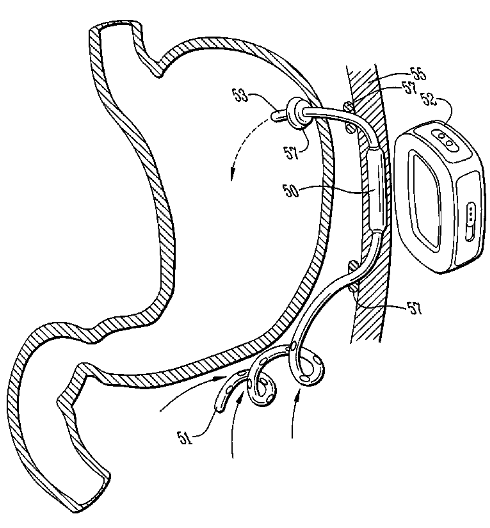
(57) **ABSTRACT**

A subcutaneous pump is provided to drain excess patient fluid from a first bodily location and discharge into a second bodily location. The pump is made from elongated flexible tube, an anchor, a check valve and then also magnetic or magnetizable material. The tube extends between a fenestrated intake end left loose in the first location (e.g., peritoneal cavity) and a discharge end for the second location (e.g., stomach or bladder). The anchor affixes the discharge end into the second location. The tube furthermore has a specified medial zone to be embedded in the subcutaneous layer of the patient's abdominal wall. The check valve is disposed inside the tube anywhere between the medial zone and the discharge end. The magnetic or magnetizable material is disposed in or around the specified medial zone and adapted to induce fluid pumping through the specified medial zone in response to an applied magnetic field.

16 Claims, 10 Drawing Sheets



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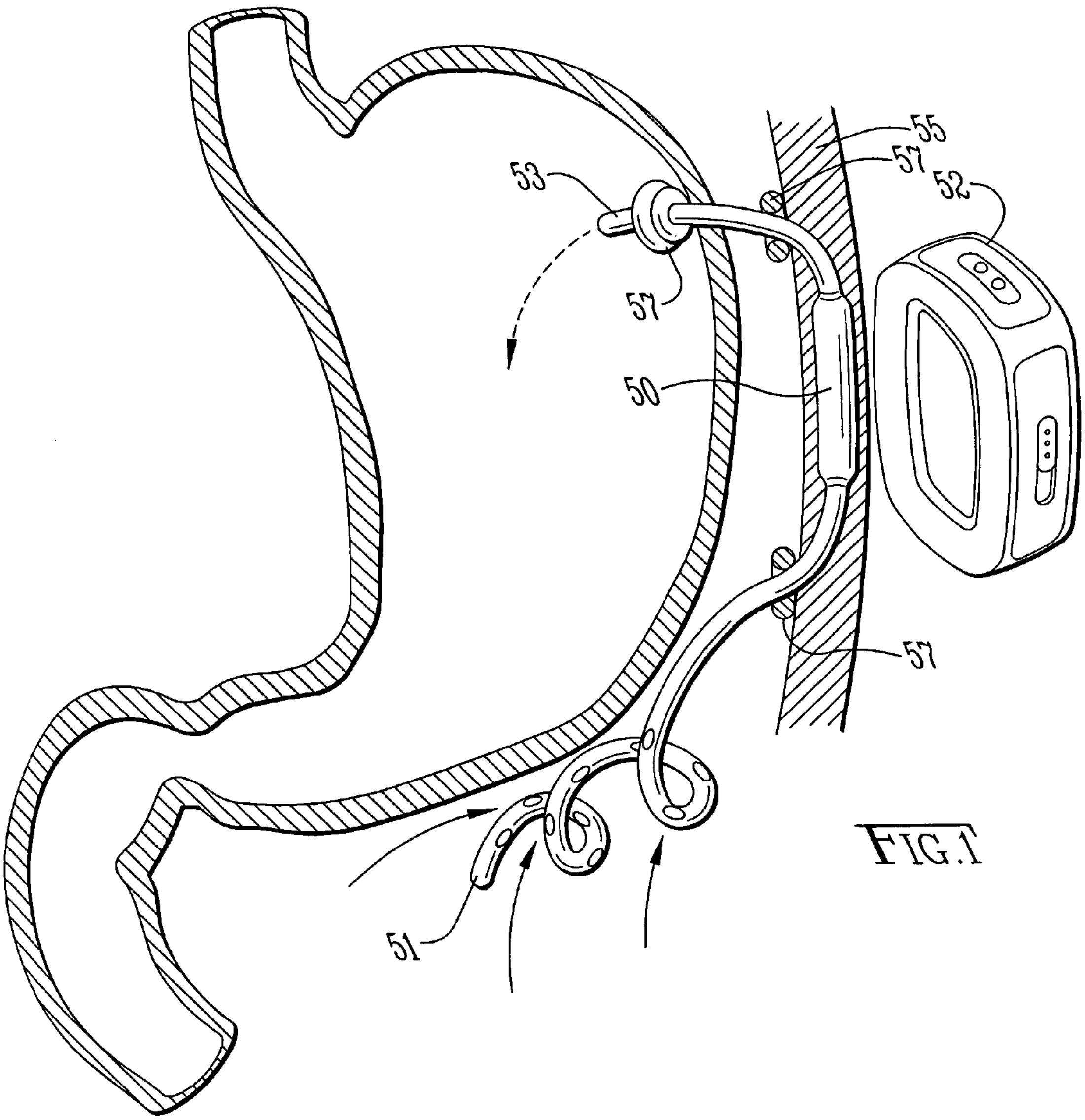

FIG.1

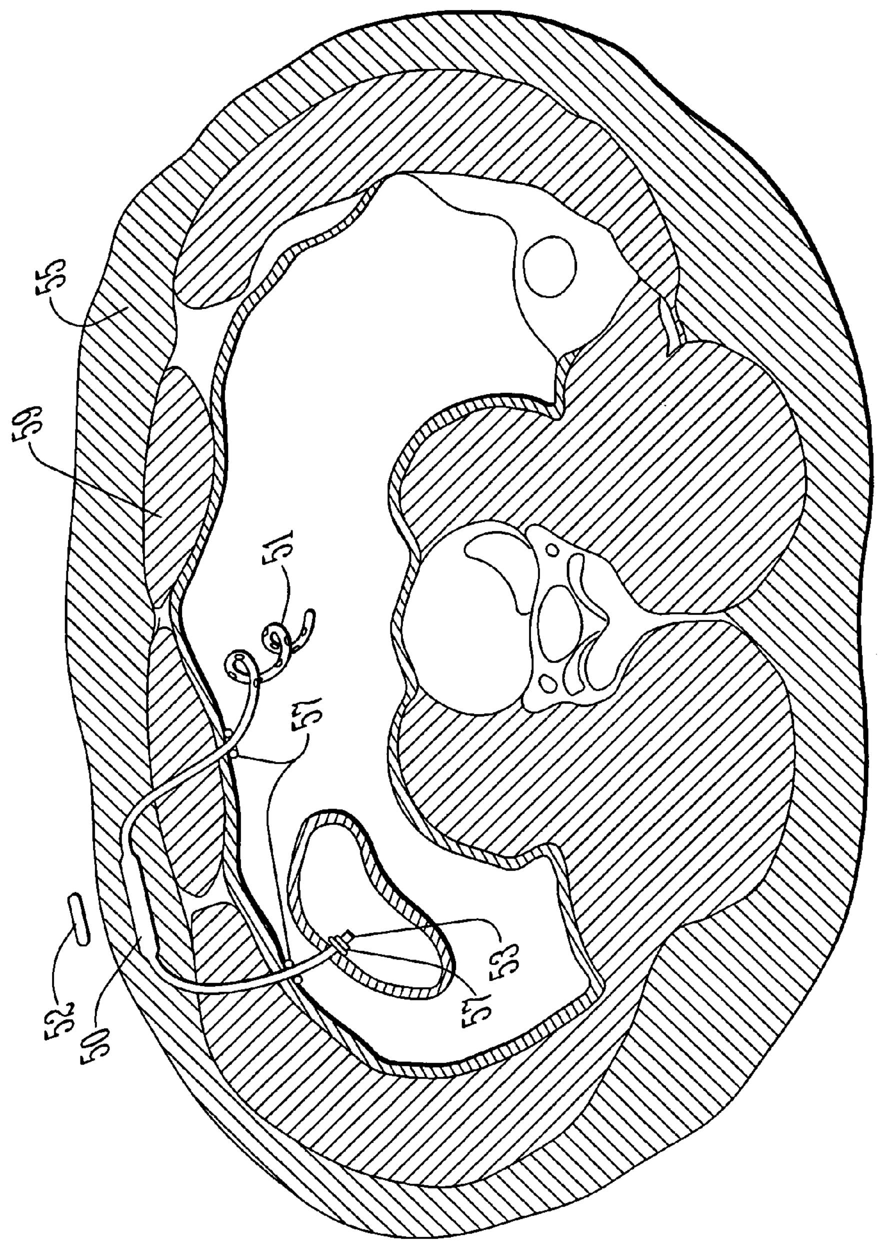

FIG. 2

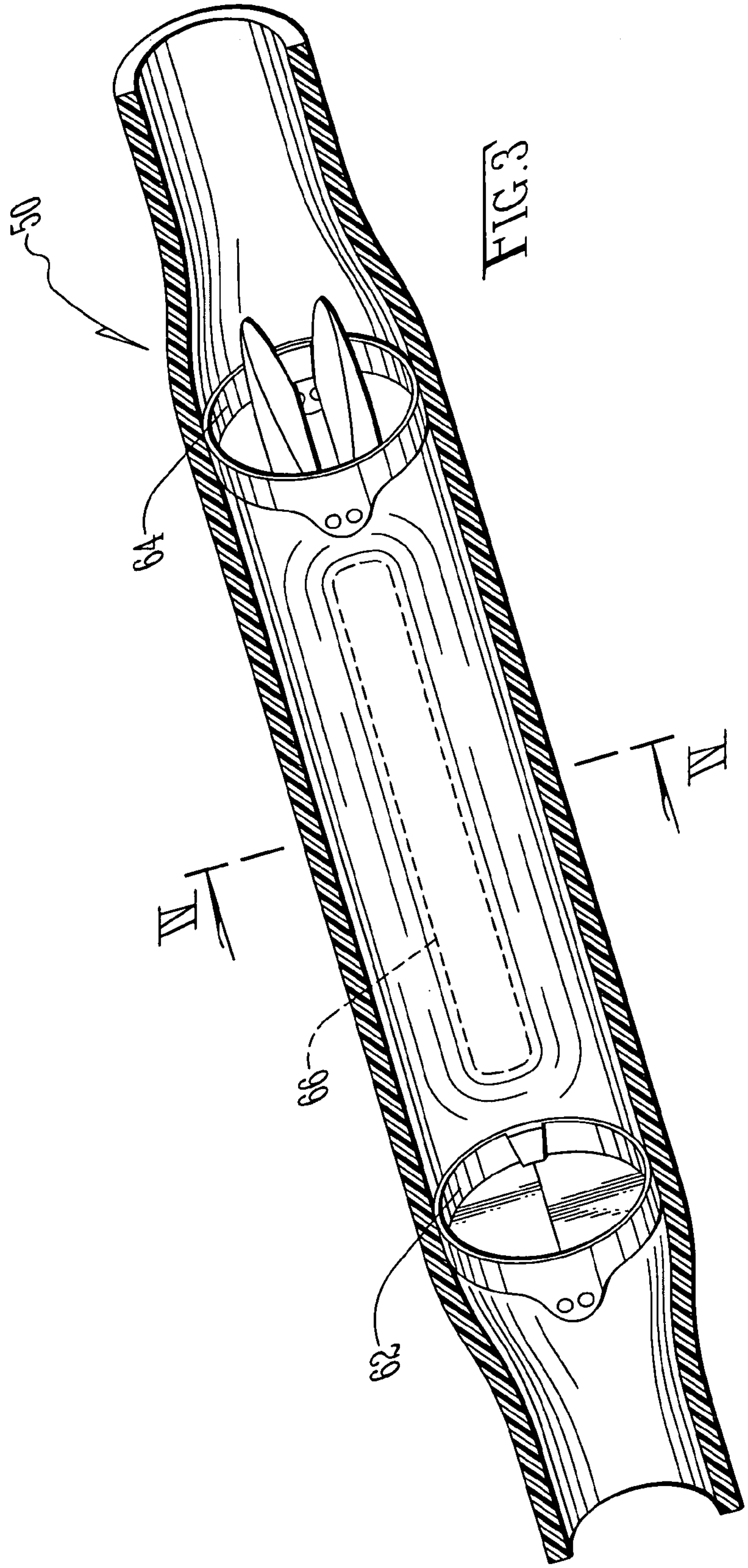

FIG.3

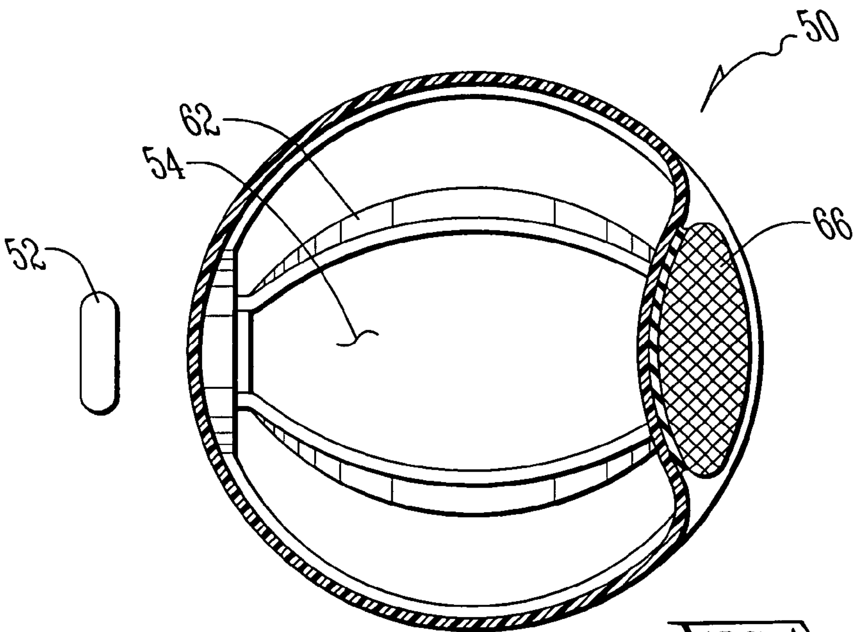

FIG.4

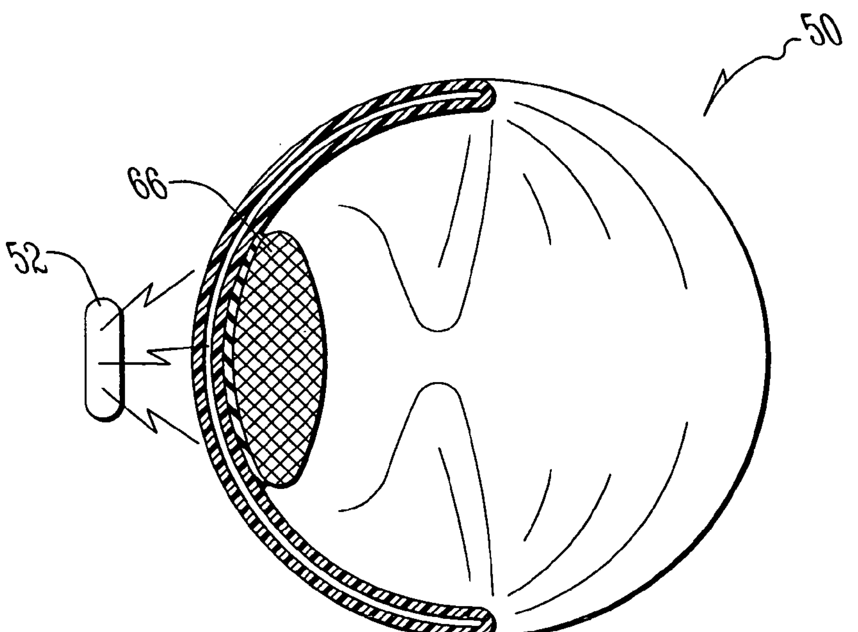

FIG.5

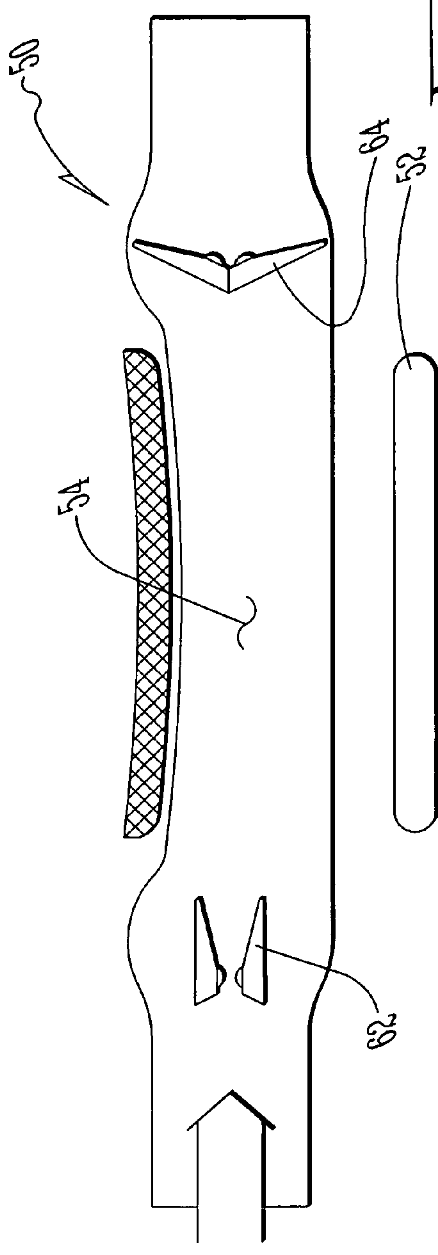

FIG.6

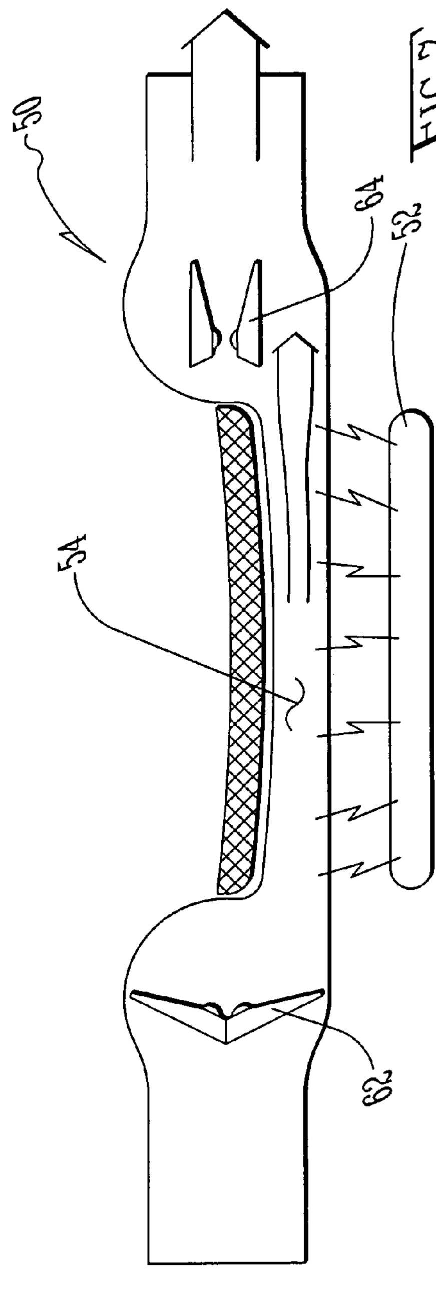

FIG.7

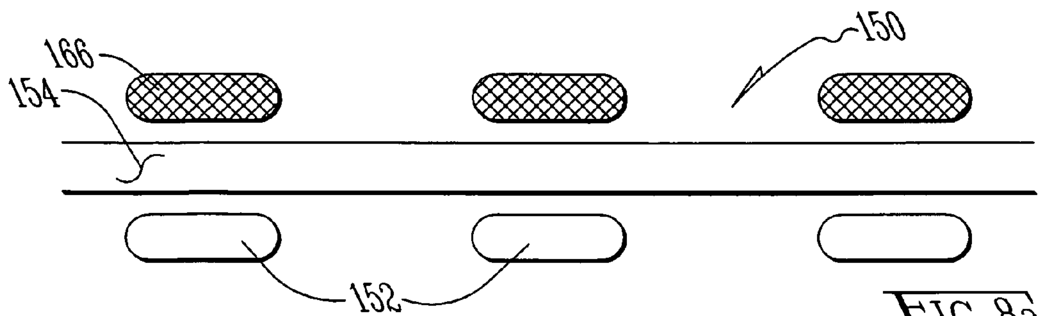

FIG. 8a

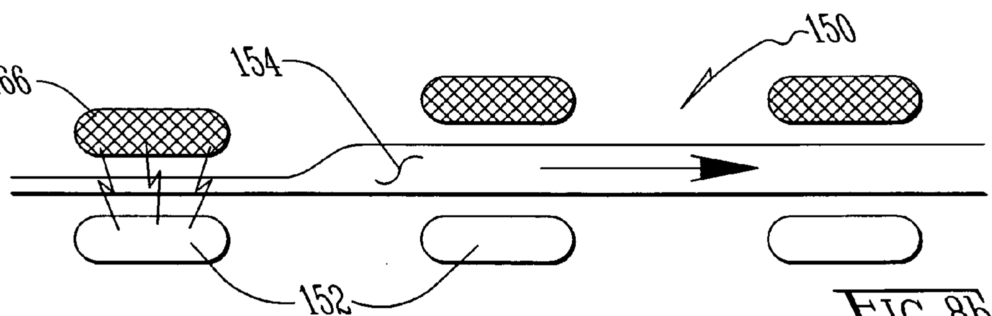

FIG. 8b

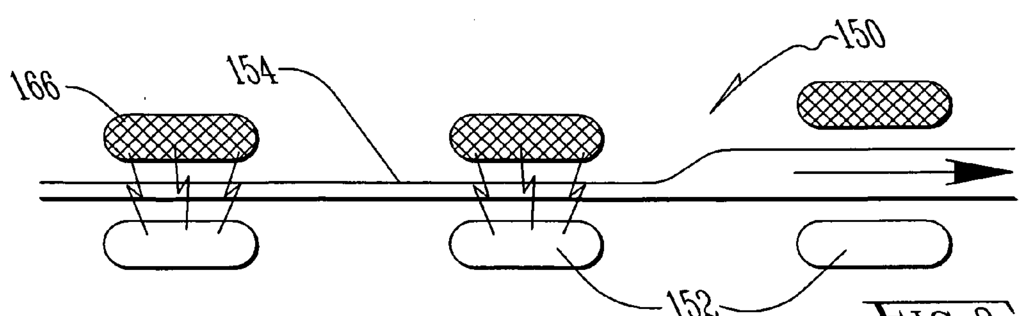

FIG. 8c

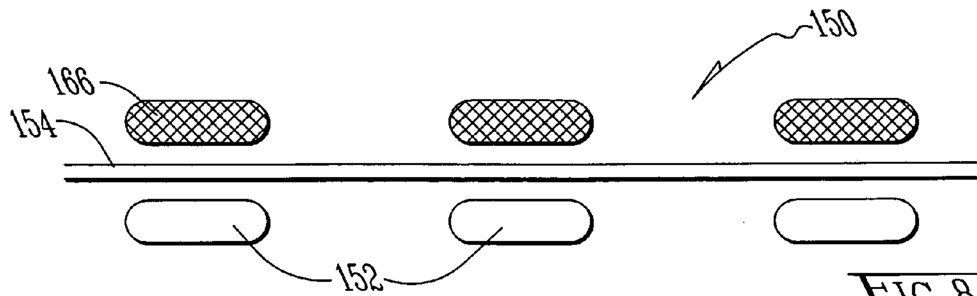

FIG. 8d

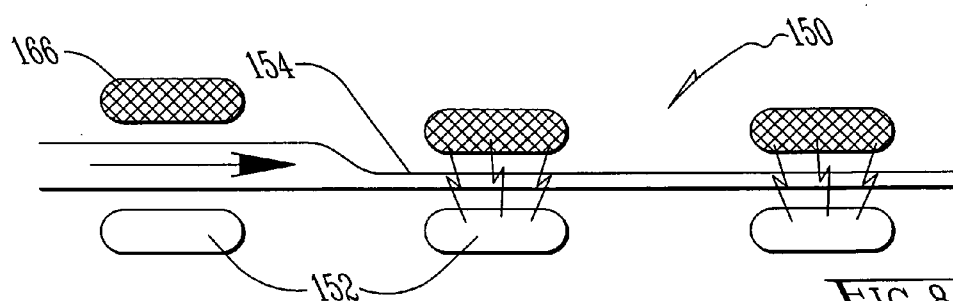

FIG. 8e

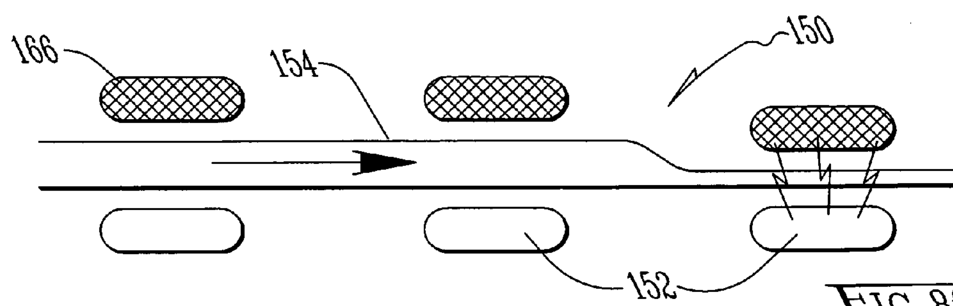

FIG. 8f

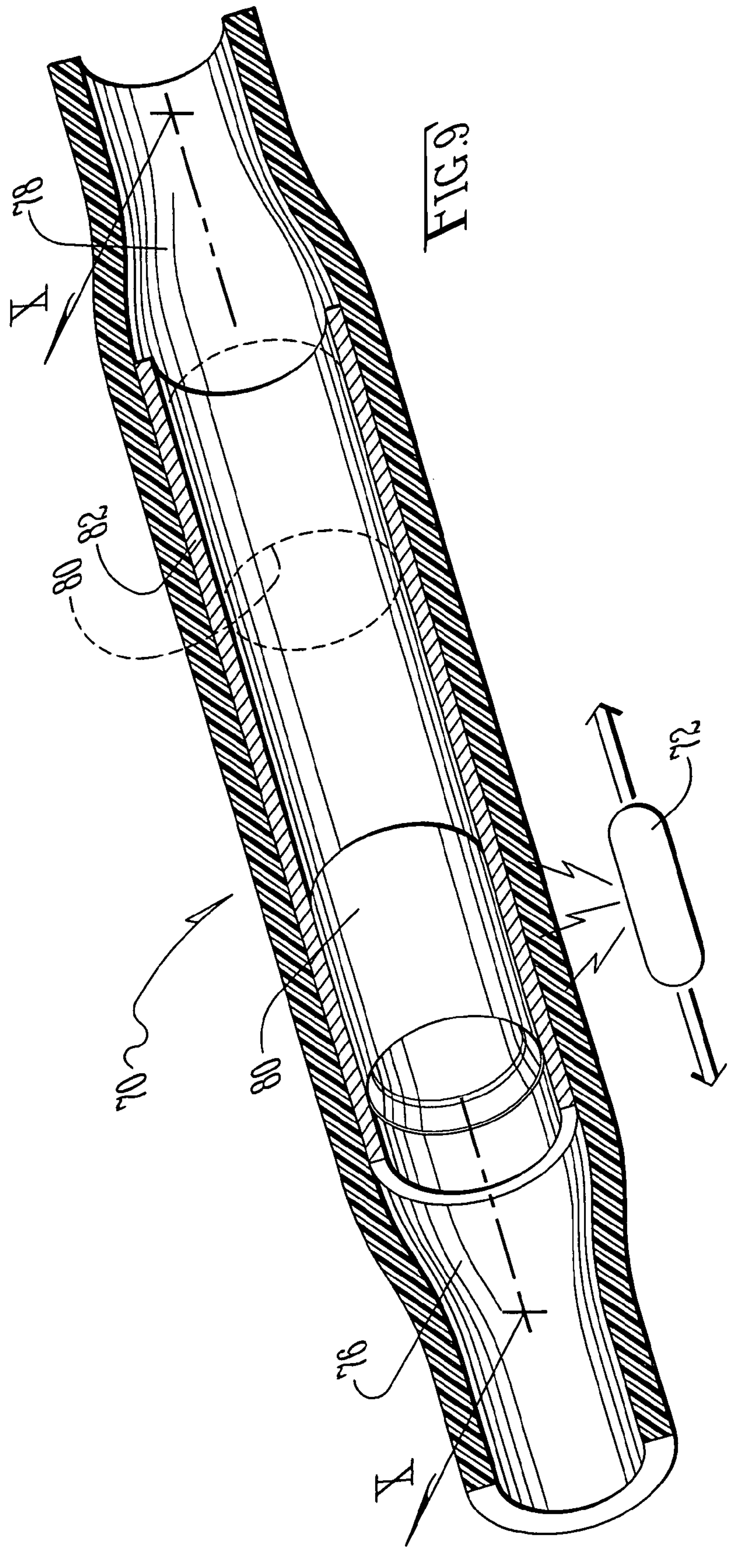

FIG. 9

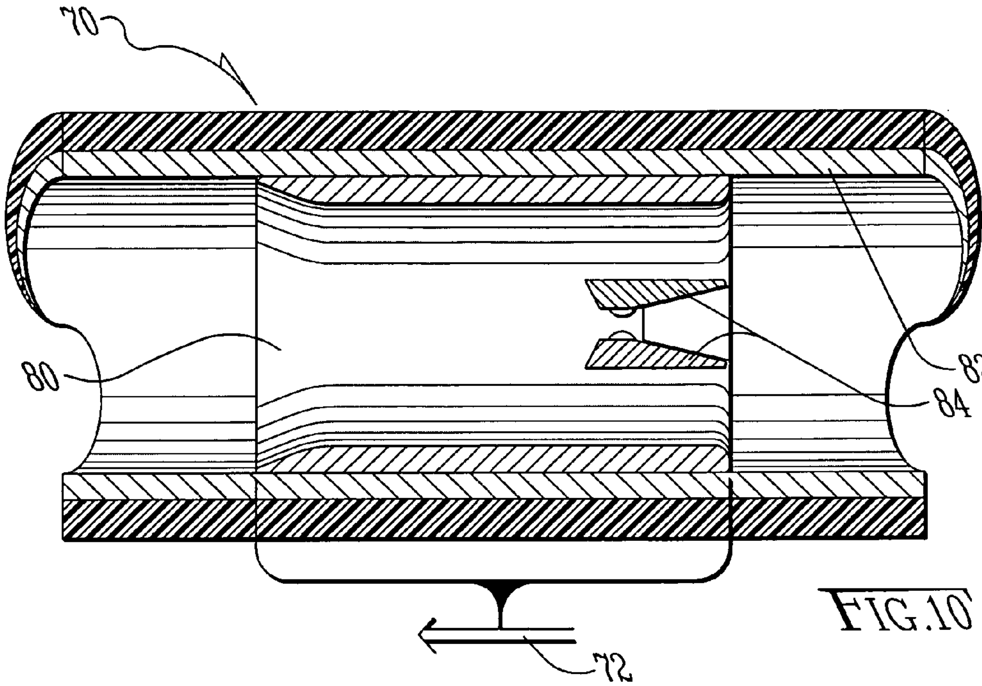

FIG.10

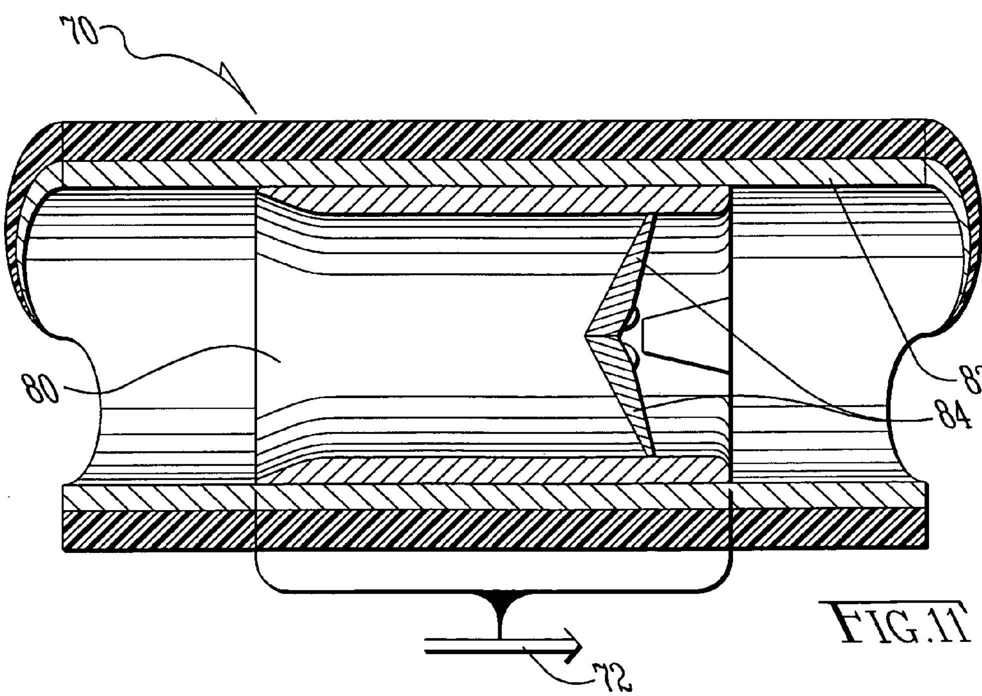

FIG.11

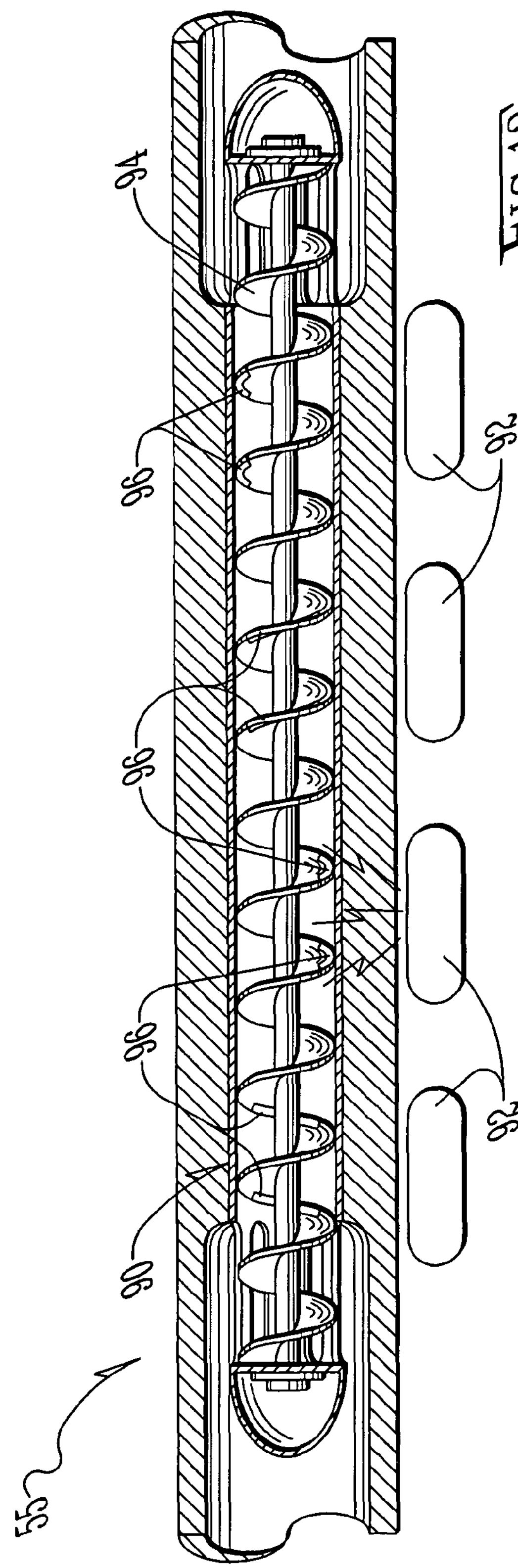

FIG.12

SUBCUTANEOUS FLUID PUMP

BACKGROUND AND SUMMARY OF THE INVENTION

The invention relates to medical procedures and, more particularly, to a subcutaneous fluid pump for a living patient that drains excess fluid from a first location and discharges into a second location, such as and without limitation the patient's bladder and/or stomach.

A number of additional features and objects will be apparent in connection with the following discussion of the preferred embodiments and examples with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

There are shown in the drawings certain exemplary embodiments of the invention as presently preferred. It should be understood that the invention is not limited to the embodiments disclosed as examples, and is capable of variation within the scope of the skills of a person having ordinary skill in the art to which the invention pertains. In the drawings,

FIG. **1** is a stylized abdominal section view showing a subcutaneous pump and its controller in accordance with the invention, wherein portions of a human abdomen are shown to illustrate the preferred embedded location therefor;

FIG. **2** is an abdominal section view comparable to FIG. **1** except taken through or near to the transpyloric plane;

FIG. **3** is a longitudinal section view of the FIG. **1** pump on an enlarged scale;

FIG. **4** is an enlarged scale sectional view taken along the cutting line IV-IV in FIG. **3**;

FIG. **5** is a sectional view comparable to FIG. **4** except showing the pump having undergone a pumping stroke;

FIG. **6** is a longitudinal section view comparable to FIG. **3** and showing the intake stroke comparable to FIG. **4**;

FIG. **7** is a longitudinal section view comparable to FIG. **6** and showing the pumping stroke of FIG. **5**;

FIG. **8** comprises a series of sectional views FIGS. **8**(*a*) through **8**(*f*) of another embodiment of a subcutaneous pump in accordance with the invention, which pump has a peristaltic pumping action;

FIG. **9** is a perspective view of an alternate embodiment of a subcutaneous pump in accordance with the invention,

FIG. **10** is an enlarged scale sectional view taken along the cutting line X-X in FIG. **9**, and showing the pump during an intake stroke;

FIG. **11** is a sectional view comparable to FIG. **10** except showing the pump during a pumping stroke; and

FIG. **12** is a perspective view of an additional embodiment of a subcutaneous pump in accordance.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **1** through **7** show a first embodiment of a subcutaneous pump **50** in accordance with the invention, along with its controller **52**. In this example use environment, the pump **50** is implanted inside the abdomen of a patient, and will drain excess fluid from a first location, then discharge the excess fluid in a second location. As shown in FIGS. **1** and **2**, the second location is a stomach.

More particularly, the pump **50** is housed in a single continuous length of flexible tubing from the fenestrated intake end **51** left loose in the peritoneal cavity to the discharge end **53** spilling into the stomach. There are many suitable polymer

materials for such flexible tubing. Again, aside from some optional O-rings **57** or other sort of clips or retainers, the pump **50** is housed in a single continuous length of flexible tubing.

Hence the pump portion **50** of the tubing is merely a specified medial zone in the tubing and flanked by one length of tubing which forms the fenestrated intake end **51** and an another length of tubing that terminates in the discharge end **53**. The flanking lengths of tubing are not required to be and will not likely be the same length. Indeed, it is expected that the fenestrated intake end **51** will be the relatively lengthier length of tubing.

It is aspect of the invention to embed the specified zone of the tubing that houses the inner workings of the pump **50** in the subcutaneous layer **55** of the patient's abdominal wall. Preferably the pump portion **50** is disposed entirely within the subcutaneous layer **55** only (which is approximately the same as the skin and superficial fascia layer). Preferably the pump portion **50** is not placed at the interface between the subcutaneous layer **55** and muscle **59**.

The flanking tube ends will penetrate out of the subcutaneous layer **55** on opposite ends of the pump. The fenestrated intake end **51** will be disposed dangling loosely in the peritoneal cavity. The discharge end will transit the peritoneal cavity and the gastric wall to be disposed discharging into the stomach. Optional retainers **57** or other sort of fasteners may be used to hold things in position.

FIG. **3-7** shows that this pump **50** is a form of a positive displacement pump. The pump **50** has a plenum **54**, the plenum **54** extends longitudinally between an inlet check valve **62** and an outlet check valve **64**, respectively.

In at least the general description above, this pump **50** share similarities with a pumping steam trap as disclosed by for example U.S. Pat. No. 5,938,409—Radle, Jr. et al.

However, in the subcutaneous pump **50** in accordance with the invention it is desirable to use medical grade check valves designed for implant use, such as and without limitation the artificial heart valve disclosed by U.S. Pat. No. 5,397,347—Cuilleron et al. Check valves such as these open and close under very low pressure gradients.

The plenum **54** has a sidewall and affixed on or in the sidewall is an elongated strip **66** of material that responds to an applied magnetic field. Such material may be referred to as magnetic or magnetizable material. The material of the strip **66** need not be a permanent magnet, but it does need to respond to an applied magnetic field. FIG. **1** and shows that controller **52** is preferably worn on the patient's body just outside a very close location to the subcutaneous pump **50**. The controller **52** is configured to provide a fluctuating magnetic field to make the pump **50** operate without having to have a physical link.

FIG. **4** is a cross-section view through the plenum **54** and strip **66** in the absence of an applied magnetic field. FIG. **6** is a counterpart longitudinal section view. The pump portion **50** of the flexible tubing has sufficient shape memory to more or less restore the plenum **54** to a more or less cylindrical shape after every cycle of being deformed to a collapsed state. FIGS. **5** and **7** show the application of a magnetic field by the controller **52**. The strip **66** will be induced to move toward the arc of the sidewall that is 180° opposite from the strip **66**, hence causing the plenum **54** to collapse. The end of the pumping stroke is shown by FIGS. **5** and **7**.

When the plenum collapses as in FIGS. **5** and **7**, the fluid inside the plenum **54** initially rises so slightly in pressure. But the pressure rise is sufficient to pressurize the inlet check valve **62** to CLOSE and concurrently as to pressurize the outlet check valve **64** to OPEN. As the plenum **54** collapses further, a volume of fluid is pumped out the outlet check valve **64** as it remains open. The pumping stroke produces a pumped pulse of fluid corresponding to a substantial fraction of the plenum **54**'s volume at its maximum open volume.

FIGS. **4** and **6** show the effect when the controller **52** performs a control action which corresponds to an intake stroke. The controller **52** might just switch OFF the applied field, and the plenum **54** might have enough inherent shape memory that it will restore itself to the shape shown in FIGS. **4** and **6**. Alternatively, the controller **52** might apply a magnetic field with different properties, such as reverse polarity, to drive the strip **66** and/or plenum **54** open.

This will cause the collapsed, minimized volume of the plenum **54** to open up. With the volume increasing, the fluid pressure in the plenum **54** will initially drop slightly in pressure, causing a slight suction pressure. This activity will suction the outlet check valve **64** to CLOSE and suction the inlet check valve **82 62** to OPEN. Hence the result is an intake stroke.

Needless to say, the pump **50** follows an intake stroke with another pumping stroke, and so on, indefinitely as the controller **52** is configured or operated to do so.

The controller **52** produces a small magnetic field to cause the pump **50** to pump. Preferably but not to exclusion of alternatives, the controller comprises electromagnets that preferably operate on DC power which are believed to requires material cores (i.e., not air cores like AC electromagnets). The DC electromagnets can have either permanent magnet cores or else magnetic and/or magnetizable cores.

It is believed that the strength of the magnetic field can be fairly weak, partly due to the close physical proximity between the controller **52** and the reactive strip **66**. A weak magnetic field so that the patient travel normally without being a source of magnetic interference of too many electric products or devices, belonging to the patients or others.

Also, no doubt the modern world is filled with all sorts of magnetic fields produced from all sorts of consumer devices (e.g., televisions) to municipal, industrial and commercial security systems (e.g., RFID readers beside protected doorways). It is believed that such fields may interfere with the subcutaneous pump **50**. However, it is also believed that the interference in most cases will be temporary, and, not life threatening to the patient.

Unlike a heart valve, where the patient doesn't want to miss a beat, a patient with this subcutaneous pump should thrive for limited periods of inoperativeness of the pump.

It is a further aspect of the invention that the pump **50** in accordance with the invention is left permanently disposed in the subcutaneous layer of the patient. The controller **52** is designed to provide control signals, to provide feedback to the patient such as for inoperativeness because of interference from an external magnetic field, and other features too. For example, the controller **52** might be configured not only to move the strip **66** between flexion and extension, but also sense the position of the strip **66**. That way, the controller **66** can detect the operativeness of the strip **66**, as well as estimate flow capacity. Moreover, the controller **52** might be configured to accepts inputs from other detectors (none shown) that might relate to a data signal for calculating a speed-up or slow-down of flow capacity. Additionally, the battery-life for the controller **52** is dependent on batteries in the controller **52**, which are readily accessible by the patient or assistants.

FIG. **8** comprises a series of sectional views FIGURES (a) through (f) of another embodiment of a subcutaneous pump **150** in accordance with the invention. This pump **150** has a peristaltic pumping action. This pump **150** has a plenum **154** of flexible tubing as before. Preferably the plenum **154** has shape memory such that in the absence of a magnetic field, the plenum **154** self-restores its open lumen to a cylindrical shape or the like (e.g., an axial hollow shape). In contrast to before, this pump **150** has no check valves. This pump **150** does have a plurality axially-spaced reactive strips **166** as well as a plurality of axially-spaced, localized sources **152** of magnetic fields. Preferably these localized sources **152** can be switched ON and OFF according to a predetermined sequence by an overall controller (e.g., in housing **52** as shown in FIG. **1**).

FIG. **8**(*a*) shows all the localized sources switched OFF. The plenum **154** is wide open. FIGS. **8**(*b*) through **8**(*d*) show all the localized sources **152** progressively switching ON from the intake end (e.g., the left end in the view) to the outlet end (e.g., the right end in the view) to cause the original volume of fluid in the wide open plenum **154** to be squeezed through the outlet (e.g., the right end of the view). The foregoing comprises the pumping stroke.

The preferred manner of intake stroke in FIGS. **8**(*e*), **8**(*f*) and **8**(*a*). All the localized sources **152** progressively switch OFF from the intake end (e.g., the left end in the view) to the outlet end (e.g., the right end in the view) to the progressively opening plenum to suction in a new volume of fluid from the inlet (e.g., the left end of the view).

FIG. **9** shows an alternate embodiment of a subcutaneous pump **70** in accordance with the invention. This pump **70** has a plenum **74** extending between and an inlet **76** and outlet **78**, and also has a miniature slide **80** contained inside the plenum **74** and given the freedom of movement to reciprocate between the inlet **76** and outlet **78**. The slide **80** slides in a slideway **82**.

The slide **80** is preferably made of a material that responds to an applied magnetic field. The material of the slide **80** need not be a permanent magnet, but it does need to respond to an applied magnetic field. Here, the controller **72** reciprocates the slide **80** between a position shown in solid line for it, to a position shown in dashed lines.

The solid line location of the slide **80** corresponds to about the end of its intake stroke. The dashed line location of the slide **80** corresponds to about the end of its pumping stroke.

FIG. **10** shows that this embodiment of the pump **70** only has a single check valve **84**. The lone check valve **84** is mounted in the slide **80**. As the slide **80** is driven towards the intake end (e.g., the left in this view), the check valve **84** is open glides through the fluid that fills the plenum **74**. FIG. **11** shows the check valve **84** being driven toward the outlet **78** end. Here the single check valve **84** shuts, and the fluid in the plenum **74** is pumped out the outlet **78**. At the same time, however, fluid from the feed pipes is being suctioned in through the inlet **76** to back fill the plenum **74** as the slide **80** is driving at the former volume of fluid that last occupied the plenum **74**.

FIG. **12** is a perspective view of an additional embodiment of a subcutaneous pump **90** in accordance. Again, the pump **90** is a specified zone of single continuous piece of flexible tubing between and intake end and a discharge end (e.g., see FIGS. **1** and **2**, but not shown in this view). The intake end is disposed inside the peritoneal cavity. The discharge end is disposed inside some other target location like the stomach or bladder.

The specified zone of the pump **90** which contains the inner workings of the pump **90** is embedded in the subcutaneous layer **55** of the patient's abdominal wall. Preferably the pump portion **90** is disposed entirely within the subcutaneous layer **55** only (which is approximately the same as the skin and superficial fascia layer). Preferably the pump portion **90** is not placed at the interface between the subcutaneous layer **55** and muscle.

This pump **90** has a plenum and inside the plenum is an elongated miniature auger **94**. Like the FIG. **8** embodiment, this pump **90** has a plurality axially-spaced reactive strips **96** as well as a plurality of axially-spaced, localized sources **92** of magnetic fields. Preferably these localized sources **92** can be switched ON and OFF according to a predetermined sequence by an overall controller (e.g., as housed inside a housing **52** as shown in FIG. **1**).

The reactive strips **66** are placed on the outer edge of the helical flight of the auger **94** at axially-spaced locations, and, at respectfully angularly-distributed locations as well. Here, there are four (4) such axial strips **66** and each succeeding one is rotated 90° (ninety degrees) counter-clockwise from the preceding strip **66**. Each localized source **92** can be energized one at a time such that the localized source **92** locks on its respective axial counterpart reactive strip **66** and pulls the strip **66** closest to the wall to the source **92**.

For example, in FIG. **12**, the magnetic-field source **92** second from left is energized (the are switched OFF), and, it has pulled the reactive strip **96** also second from the left straight down to the six o'clock position.

The next sequence of events would be switching OFF the source second from left and switching ON concurrently the source third from left. This will index the helical flight of the auger **94** around by 90° (ninety degrees).

Switching OFF the source third from left concurrently while switching ON the source fourth from left (e.g., the one on the end on the right) will index the helical flight of the auger **94** around by 90° (ninety degrees).

Switching OFF the source fourth from left concurrently while switching ON the source first on the left will index the helical flight of the auger **94** around by 90° (ninety degrees). And so on, that by the time the condition is returned to as shown in FIG. **12**, the auger will have rotated 90°. The rotation of the auger need not be continuous. It can be in steps.

Preferably, the helical flight of the auger **94** as well as the rest of the auger assembly (excluding the reactive strips **96**) are preferably made of non-magnetic materials.

The invention having been disclosed in connection with the foregoing variations and examples, additional variations will now be apparent to persons skilled in the art. The invention is not intended to be limited to the variations specifically mentioned, and accordingly reference should be made to the appended claims rather than the foregoing discussion of preferred examples, to assess the scope of the invention in which exclusive rights are claimed.

What is claimed is:

1. A subcutaneous pump configured to drain excess fluid from a first bodily location in a patient and discharges into a second bodily location, comprising:

a single continuous length of elongated flexible tube having a continuous sidewall extending between an intake end for leaving loose in the first location, comprising the peritoneal cavity, and, a discharge end for discharging the excess patient fluid in the second location, comprising a target organ or a gland;

said single continuous length of elongated flexible tube having a specified medial zone adapted to be embedded in the subcutaneous layer of the patient's abdominal wall;

said single continuous length of elongated flexible tube being made from such a flexible material that has sufficient shape memory properties such that if tube sidewall in the specified medial zone is collapsed by an applied external force, then after the removal of the applied external force the shape memory properties of the tube material will restore the specified medial zone to defining a central lumen generally ranging from a cylindrical shape to at least an axially hollow shape;

said central lumen of the specified medial zone comprising a plenum all within the specified medial zone and axially extending between a relative inlet portion and an axially spaced apart relative outlet portion;

wherein the tube sidewall in the specified medial zone has axially-extending, angularly delimited zones comprising at least a proximal angularly delimited zone configured to face the patient's skin and a distal angularly delimited zone configured to face the patient's peritoneal cavity;

an elongated strip of magnetic or magnetizable material affixed on or in the either proximal angularly delimited zone of the tube sidewall or else the distal angularly delimited zone of the tube sidewall;

whereby a fluctuating magnetic field causes the tube sidewall of the specified medial zone to distort the plenum.

2. The subcutaneous pump of claim **1**, wherein:

the elongated strip of magnetic or magnetizable material are affixed on or in the distal angularly delimited zone of the tube sidewall;

whereby an applied magnetic field causing attraction of the elongated strip of magnetic or magnetizable material will consequently cause the collapse of the plenum.

3. The subcutaneous pump of claim **2**, further comprising:

an intake check valve disposed inside the tube proximate the relative intake portion of the plenum.

4. The subcutaneous pump of claim **3**, further comprising:

an outlet check valve disposed inside the tube proximate the relative outlet portion of the plenum.

5. The subcutaneous pump of claim **2**, further comprising:

an outlet check valve disposed inside the tube proximate the relative outlet portion of the plenum.

6. The subcutaneous pump of claim **2**, further comprising:

a remote source of an applied magnetic field outside of the patient's body and proximate the specified medial zone;

a correspondingly remote controller for said magnetic field source;

wherein when the controller comprises first and second states;

the first state comprises energizing the magnetic field source to create an applied magnetic attraction force on the elongated strip of magnetic or magnetizable material, wherein the plenum collapses and whereby corresponding to a pumping stroke.

7. The subcutaneous pump of claim **6**, further comprising:

the second state comprises switching the magnetic field source OFF, wherein the shape memory properties the tube sidewall's flexible material in the specified medial zone will cause the collapsed plenum to restore to being an open central lumen generally ranging from a cylindrical shape to at least an axially hollow shape, and whereby corresponding to an intake stroke.

8. The subcutaneous pump of claim **6**, wherein:

the second state comprises switching the magnetic field source to create an applied magnetic repulsion force on the elongated strip of magnetic or magnetizable material, wherein the plenum restores to being an open central lumen generally ranging from a cylindrical shape to at least an axially hollow shape, and whereby corresponding to an intake stroke.

9. A subcutaneous pump configured to drain excess fluid from a first bodily location in a patient and discharges into a second bodily location, comprising:

a single continuous length of elongated flexible tube having a continuous sidewall extending between an intake end for leaving loose in the first location, comprising the peritoneal cavity, and, a discharge end for discharging the excess patient fluid in the second location, comprising a target organ or a gland;

said single continuous length of elongated flexible tube having a specified medial zone adapted to be embedded in the subcutaneous layer of the patient's abdominal wall;

said single continuous length of elongated flexible tube being made from such a flexible material that has sufficient shape memory properties such that if tube sidewall in the specified medial zone is collapsed by an applied external force, then after the removal of the applied external force the shape memory properties of the tube material will restore the specified medial zone to defining a central lumen generally ranging from a cylindrical shape to at least an axially hollow shape;

said central lumen of the specified medial zone comprising a plenum all within the specified medial zone and axially extending between a relative inlet portion and an axially spaced apart relative outlet portion;

wherein the tube sidewall in the specified medial zone has axially-extending, angularly delimited zones comprising at least a proximal angularly delimited zone configured to face the patient's skin and a distal angularly delimited zone configured to face the patient's peritoneal cavity;

a series of axially spaced elements of magnetic or magnetizable material affixed on or in the either proximal angularly delimited zone of the tube sidewall or else the distal angularly delimited zone of the tube sidewall;

whereby a repetitive, axially progressing applied magnetic field starting from the relative intake portion to the relative outlet portion, and then starting over at the relative intake portion, causes the tube sidewall of the specified medial zone to distort the plenum in a peristaltic action.

10. The subcutaneous pump of claim **9**, wherein:

the series of axially spaced elements of magnetic or magnetizable material are affixed on or in the distal angularly delimited zone of the tube sidewall;

whereby a repetitive, axially progressing applied magnetic field causing axially progressive magnetic attraction of the series of axially spaced elements of magnetic or magnetizable material will consequently cause the progressive collapse of the plenum from the relative intake portion to the relative outlet portion, whereby resulting in a peristaltic pumping action.

11. The subcutaneous pump of claim **10**, further comprising:

a remote source of an applied magnetic field outside of the patient's body and proximate the specified medial zone;

a correspondingly remote controller for said magnetic field source;

wherein when the controller comprises first and second states;

the first state comprises energizing the magnetic field source to create an axially progressive magnetic attraction field on the series of axially spaced elements of magnetic or magnetizable material, progressing from the relative intake portion to the relative outlet portion.

12. The subcutaneous pump of claim **11**, further comprising:

the second state comprises progressively de-energizing the magnetic field to OFF from the relative intake portion to the relative outlet portion, wherein the shape memory properties the tube sidewall's flexible material in the specified medial zone will cause the collapsed plenum to progressively restore from the relative intake portion to the relative outlet portion to being an open central lumen generally ranging from a cylindrical shape to at least an axially hollow shape, and whereby corresponding to an intake stroke.

13. The subcutaneous pump of claim **11**, wherein:

the second state comprises progressively energizing the magnetic source to create an axially progressive magnetic repulsion field on the series of axially spaced elements of magnetic or magnetizable material from the relative intake portion to the relative outlet portion, causing the collapsed plenum to progressively restore from the relative intake portion to the relative outlet portion to being an open central lumen generally ranging from a cylindrical shape to at least an axially hollow shape, and whereby corresponding to an intake stroke.

14. A subcutaneous pump configured to drain excess fluid from a first bodily location in a patient and discharges into a second bodily location, comprising:

a single continuous length of elongated flexible tube having a continuous sidewall extending between an intake end for leaving loose in the first location, comprising the peritoneal cavity, and, a discharge end for discharging the excess patient fluid in the second location, comprising a target organ or a gland;

said single continuous length of elongated flexible tube having a specified medial zone adapted to be embedded in the subcutaneous layer of the patient's abdominal wall;

said single continuous length of elongated flexible tube being made from such a flexible material that has sufficient shape memory properties such that if tube sidewall in the specified medial zone is collapsed by an applied external force, then after the removal of the applied external force the shape memory properties of the tube material will restore the specified medial zone to defining a central lumen generally ranging from a cylindrical shape to at least an axially hollow shape;

said central lumen of the specified medial zone comprising a plenum all within the specified medial zone and axially extending between a relative inlet portion and an axially spaced apart relative outlet portion;

a reciprocating body of magnetic or magnetizable material disposed inside the plenum to reciprocate back and forth between the relative intake portion and relative outlet portion;

whereby a magnetic field driving reciprocating body to reciprocate back and forth in the plenum causes a pumping action.

15. The subcutaneous pump of claim **14**, further comprising:

at least one check valve disposed any of:—

- inside the tube proximate the relative intake portion of the plenum;
- inside the tube proximate the relative outlet portion of the plenum; and/or
- wherein the reciprocating body has a flow passage formed therein or thereon, and therefore inside the flow passage of the reciprocating body.

16. The subcutaneous pump of claim **15**, further comprising:

a remote source of an applied magnetic field outside of the patient's body and proximate the specified medial zone;

a correspondingly remote controller for said magnetic field source;

wherein when the controller controls the magnetic field source to drive the reciprocating body to reciprocate back and forth between the relative intake portion and relative outlet portion.

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